Title:
Evaluating the Promise of the *FUSION* Tier 2 Math Intervention

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Background / Context:
The low level of mathematics performance of U.S. students in relation to national standards and in international comparisons has concerned educators and policy makers for many years (National Research Council, 2001). Though a slight improvement from previous years, results from the latest NAEP (National Center for Education Statistics, 2011) indicate that only 40% of fourth-grade students were deemed at or above proficient and that 18% were below basic. Signs of these problems appear early and are long-lasting (Aud et al., 2010; Morgan, Farkas, & Wu, 2009). Even at school entry, significant differences in student knowledge reliably appear on measures related to counting principles and number knowledge as well as more complex understandings of quantities, operations, and problem solving (Griffin, Case, & Siegler, 1994; Jordan, Kaplan, & Locuniak, 2006).

Though it is desirable for students to have the foundational mathematics knowledge they need to succeed when exposed to mathematics instruction in the early elementary grades, the reality is that many do not (Bodovski & Farkas, 2007; Duncan et al., 2007; Hanich, Jordan, Kaplan, & Dick, 2001; Morgan, Farkas, & Wu, 2009). Many struggling students' difficulties resonate with specific aspects of whole numbers, particularly in developing number sense, acquiring efficient counting strategies, and retrieving number combinations (Geary, 1993; Gersten, Jordan, & Flojo, 2005).

In line with Response to Intervention service delivery models, our research group aims to alleviate and prevent mathematics learning difficulties through effective, research-based instruction and intervention (Baker, Fien, & Baker, 2010). We posit that inclusion of research-based design elements enhances such mathematics instruction by building students' deep understanding of essential early whole number concepts and principles and procedural fluency.

With funding from an IES Development and Innovation grant (Baker, Clarke, Fien, & Chard, 2009), our group has developed *FUSION*, a Tier 2 mathematics intervention program for Grade 1 students at risk for mathematics difficulties. Our primary goals were to design a feasible and usable intervention and gather data on the promise of the intervention to foster students' conceptual understanding of whole number concepts and skills and procedural fluency. The *FUSION* curriculum was developed using an iterative design process aligned with design experiment methodology (Brown, 1992; Shavelson, Phillips, Towne, & Feuer, 2003). Brief Learning Trials in Year 1, as well as a feasibility study in Year 2 identified needed revisions in content, lesson length, structure, and formatting.

Focus of Study:
The culminating Year 3 pilot study reported here was intended to measure the extent to which the *FUSION* Tier 2 math intervention shows promise of improving math achievement of first-grade students at-risk for math difficulties.

Setting:
The pilot study took place in nine schools in two suburban school districts in the northwest. One district serves 10,796 students: 33% are minorities, 6% are English learners, 60% are eligible for free/reduced lunch, and 15% receive special education services. The other district serves 5,866 students: 28% are minorities, 3% are English learners, 55% are eligible for free/reduced lunch,

and 17% receive special education services. Several schools in each district receive Title-1 funds.

Population / Participants / Subjects:
A total of 151 students (68 female) participated. Nine district-employed interventionists (all female) provided the *FUSION* instruction. District-provided data revealed 21% of the students in our sample were minorities, 16% were English learners, 22% received special education services, and 65% were eligible for free/reduced lunch.

These students were selected through a multi-step screening process of all first graders. Screening occurred three months into the school year. Within each participating school, brief measures of number sense (EN-CBM, described below) were administered to identify the students with the lowest mathematics performance. Need was further verified by teacher recommendation and rating of performance in classroom mathematics. *FUSION*-eligible students were required to speak English, regularly attended school, could identify numbers 1-10 and could count from 1-10.

At each school, the at-risk students were randomly assigned to one of two conditions: *FUSION* Intervention or At-risk Control. Additional students were randomly selected to participate in an Average Control condition. There were generally fifteen students participating at each school (i.e., our goal was five students in each of the three conditions), however thirty students (ten in each of the three conditions) participated at one school that operated two *FUSION* groups.

Intervention:
The *FUSION* program is a Grade 1 (Tier 2) mathematics intervention that focuses specifically on building students' early knowledge of whole number concepts. Four math strands comprise the program: (a) base-10/place value, (b) basic number combinations, (c) multi-digit addition and subtraction without renaming, and (d) word problems. Each strand reflects the critical content of first grade mathematics (National Governors Association Center for Best Practices, 2010; National Council of Teachers of Mathematics, 2006) and aligns with the recommendations of the National Math Advisory Panel (2008) and other experts in the field (Kilpatrick, Swafford, & Findell 2001; Wu, 2009). *FUSION*'s 60 scripted lessons utilize an explicit instructional format. Lessons contain teacher modeling, scaffolded instructional examples, and opportunities for academic feedback. Lessons incorporate a variety of math models and offer frequent opportunities for student practice and judicious review.

FUSION instruction occurred outside of students' core math and reading time. Lessons lasted approximately 30 minutes and were delivered in small-group instructional formats, with approximately 4-5 students per group. Interventionists were encouraged to complete one lesson per day, three times per week.

Research Design:
The current study utilized a randomized control trial to examine the promise of the *FUSION* intervention. Within school, students determined at-risk for math difficulties were randomly assigned to one of two conditions, *FUSION* Intervention or At-risk Control. Additional students were randomly selected to participate in an Average Control condition. *FUSION* students

received standard district whole class instruction as well as the *FUSION* intervention (taught by school personnel). Both groups of control students received standard district whole class instruction. They were not precluded from receiving other services. Student achievement is our primary outcome.

Data Collection and Analysis:

Student outcomes. We included both proximal and distal outcome measures targeting students' conceptual understanding and procedural fluency with whole numbers. During the screening process and again at posttest, all participants completed a group-administered modification of the Early Numeracy - Curriculum-Based Measures (EN-CBM; Clarke & Shinn, 2004) assessing quantity discrimination and identifying missing numbers in a sequence. At pretest and posttest, all participants completed the unmodified, individually-administered EN-CBM assessing number identification, quantity discrimination, identifying missing numbers, and oral counting as well as the group-administered Stanford Achievement Test – Tenth Edition (SAT-10) *problem solving* and *procedures* subtests. Students in the two at-risk conditions also completed ProFUSION, a researcher-developed assessment addressing key content in the *FUSION* intervention. Students were asked to write numbers from dictation, identify numbers and numbers missing from a sequence, write numbers matching base ten block models, decompose double digit numbers, and complete story problems as well as timed and untimed addition/subtraction problems.

FUSION instruction observation data. We conducted three formal observations of *FUSION* instruction for each group. Observations were coded using the *FUSION* observation instrument and the Ratings of Classroom Management and Instructional Support (RCMIS; Doabler & Nelson-Walker, 2009). The *FUSION* observation instrument measures implementation fidelity of the *FUSION* program. For each activity (4-5 activities per lesson), observers documented the absence or presence of instructional design principles specified by the *FUSION* development team (e.g., models the skill or concept, provides group response opportunities, provides academic feedback). From this measure, we calculated the percentage of design principles implemented by FUSION interventionists. An overall rating of fidelity of implementation was recorded using a 7-point scale (0 = *low*, 7 = *high*). The RCMIS measures the quality of classroom instruction (11 items) across three domains: learning environment, classroom management, and the delivery of instruction. At the conclusion of each observation, observers recorded their overall impressions of 11 features of instructional quality using a 4-point holistic rating scale (1 = *not present*, 2 = *somewhat present*, 3 = *present,* and 4 = *highly present*). Inter-rater reliability was estimated as intraclass correlation coefficients ranging from .46 to .60. Current studies are beginning to empirically link the three RCMIS domains with increased student math achievement (Doabler, Baker, Kosty, Smolkowski, Clarke, Miller & Fien, 2012).

Logistics and perceptions surveys. *FUSION* interventionists and first-grade classroom teachers completed online surveys on specific features of the *FUSION* program, *FUSION*'s effect on students' mathematics engagement and knowledge, the screening process, and the "fit" of the curriculum in the school context.

Results:

Previous findings from the project's implementation studies suggest that *FUSION* is a feasible and usable Tier 2 intervention that can be implemented in authentic educational settings. As well,

data generated through a single case design (Doabler, Strand Cary, Clarke, Fien, Baker, & Jungjohann, 2012) also indicate the promise of *FUSION* to improve student math achievement.

Data for the Pilot Study described here have been collected and are currently being analyzed. We are particularly interested in whether at-risk students receiving *FUSION* outperform at-risk students who did not receive *FUSION* and whether that performance reduces the gap between at-risk students and the "average" peers. We are also examining whether interventionists reported *FUSION* to be feasible and usable and whether gains are related to the fidelity with which interventionists implemented *FUSION*. We expect to find *FUSION* participation is associated with increased student performance on proximal measures (i.e., ProFUSION and EN-CBMs) and distal measures of student achievement (i.e., SAT-10).

Promising Pilot Study results coupled with previous findings will indicate we achieved our aim of creating a first-grade, Tier 2 mathematics intervention that is feasible and usable in schools and shows promise for increasing student achievement.

Conclusions:
This pilot study was designed to test the extent to which the *FUSION* intervention improves student achievement and is appropriate for authentic first-grade contexts. Understanding student outcomes, program implementation fidelity, and interventionists' perceptions of- and reactions to – the intervention has been a crucial piece of our iterative design process. Interventionists and classroom teachers tend to perceive meaningful effects of our curriculum (i.e., *FUSION* as well as other mathematics interventions and core curricula we've developed) on student outcomes. Proximal assessments capture these effects, but standardized measures tend not to reflect the same level of impact.

We are interested in whether – and to what extent -- our Pilot Study results reveal differential effects for proximal and distal outcomes and the degree to which measured outcomes align with teachers' perceptions of the program's utility. Such findings will inform the conversation among education researchers and the public, more generally, about the nature of research in authentic school settings and the relative importance that should be placed on different measures of a program's success. Increased consistency within – and across – studies may come from a greater focus on program intensity (i.e., dosage) or a more fine-tuned screening process or assessment net. Unfortunately, such emphases may not be deemed feasible in schools hard-pressed to fund or staff even existing levels of support. Our results and the resulting conversations will be useful to our team as we move forward with other curricula design and implementation efforts and as we finalize plans to propose - and conduct - a subsequent *FUSION* efficacy study.

Appendix A. References

Aud, S., Hussar, W., Planty, M., Snyder, T., Bianco, K., Fox, M., Frohlich, L., Kemp, J., Drake, L. (2010). *The Condition of Education 2010* (NCES 2010-028). National Center for Education Statistics, Institute of Education Sciences, U.S. Department of Education. Washington, DC.

Baker, S. K., Clarke, B., Fien, H., & Chard, D. J. (2009). *Foundations of Mathematical Understanding: Developing a Strategic Intervention On Whole Number Concepts: Project FUSION.* R324A090341. Institute of Education Sciences, U.S. Department of Education. Washington, DC.

Baker, S. K., Fien, H., & Baker, D. (2010). Robust Reading Instruction in the Early Grades: Conceptual and Practical Issues in the Integration and Evaluation of Tier 1 and Tier 2 Instructional Supports. *Focus on Exceptional Children.*

Bodovski, K., & Farkas, G. (2007). Mathematics growth in early elementary school: The roles of beginning knowledge, student engagement, and instruction. *Elementary School Journal*, 108, 115–130. doi: 10.1086/525550

Brown, A. L. (1992). Design experiments: Theoretical and methodological challenges in creating complex interventions in classroom settings. *Journal of Learning Sciences, 2*(2) *141-178.*

Clarke, B., & Shinn, M. R. (2004). A preliminary investigation into the identification and development of early mathematics curriculum-based measurement. *School Psychology Review, 33*, 234-248.

Doabler, C., & Nelson-Walker, N. (2009). Ratings of Classroom Management and Instructional Support. Unpublished observation instrument, Center on Teaching and Learning, College of Education, University of Oregon, Eugene, OR.

Doabler, C., Baker, S., Kosty, D., Smolkowski, K., Clarke, B., Miller, S. J., & Fien, H. (Submitted 2012). Observing explicit mathematics instruction in kindergarten classrooms.

Doabler, Strand Cary, Clarke, B., Fien, H., Baker, S.K., & Jungjohann, K. (2012). Using Single-Case Design to Explore the Potential Promise of a Tier 2 Math Intervention on Student Mathematics Achievement. Poster presented at the 2012 Spring Society for Research on Educational Effectiveness, Washington, D.C.

Duncan, G. J., Dowsett, C. J., Claessens, A., Magnuson, K., Huston, A. C., Klebanov, P., Pagani, L., Feinstein, L., Engel, M., Brooks-Gunn, J., Sexton, H., Duckworth, K., & Japel, C. (2007). School readiness and later achievement. *Developmental Psychology*, 43, 1428–1446. doi: 10.1037/0012-1649.43.6.1428

Geary, D. C. (1993). Mathematical disabilities: Cognitive, neuropsychological, and genetic components. *Psychological Bulletin, 114*, 345–362.

Gersten, R., Jordan, N. C., & Flojo, J. R. (2005). Early identification and interventions for students with mathematics disabilities, *Journal of Learning Disabilities, 38,* 293–304.

Griffin, S., Case, R., & Siegler, R. S. (1994). Rightstart: Providing the central conceptual prerequisites for first learning of arithmetic to students at risk for school failure. In K. McGilly (Ed.), Classroom lessons: Integrating cognitive theory and classroom practice (pp. 24-49). Cambridge, MA: MIT Press.

Hanich, L. B., Jordan, N. C., Kaplan, D., & Dick, J. (2001). Performance across different areas of mathematical cognition in children with learning difficulties. *Journal of Educational Psychology*, 93, 615–627. doi: 10.1037/0022-0663.93.3.615

Jordan, N., Kaplan, D. O., L., & Locuniak, M. (2006). Number sense growth in kindergarten: A longitudinal investigation of children at-risk for mathematics difficulties. *Child Development*, 77, 153–177.

Kilpatrick, J., Swafford, J., & Findell, B. (2001). *Adding it up: Helping children learn mathematics*. Washington, DC: Mathematics Learning Study Committee.

Morgan, P. L., Farkas, G., & Wu, O. (2009). Five-year growth trajectories of kindergarten children with learning disabilities in mathematics. *Journal of Learning Disabilities, 42*, 306–321.

National Center for Education Statistics. (2011). The Nation's Report Card: Mathematics 2011 (NCES 2012-458). National Center for Education Statistics, Institute of Education Sciences, U. S. Department of Education, Washington, D.C.

National Council of Teachers of Mathematics. (2006). *Curriculum Focal Points for prekindergarten through grade 8 mathematics: A quest for coherence*. Retrieved from http://www.nctm.org/standards/focalpoints.aspx?id=282

National Governors Association Center for Best Practices, Council of Chief State School Officers. (2010). Common Core State Standards - Mathematics. (2010). National Governors Association Center for Best Practices, Council of Chief State School Officers. Washington, D.C.

National Mathematics Advisory Panel. (2008). *Foundations for Success: The Final Report of the National Mathematics Advisory Panel,* U.S. Department of Education: Washington, DC.

National Research Council. (2001). Adding it up: Helping children learn mathematics. Washington, DC: Mathematics Learning Study Committee.

Shavelson, R. J., Phillips, D. C., Towne, L., & Feuer, M. J. (2003). One the science of education design studies. *Educational Researcher*, 32(1), 25-28.

Wu, H. (2009, Fall). What's sophisticated about elementary mathematics? Plenty – that's why elementary schools need math teachers, *American Educator,* 4-11.